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Effective Mathematics Lesson from the Lenses of Primary Pupils: Preliminary Analysis

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Abstract

This paper discusses the preliminary findings of a larger study which aims to explore the elements of effective mathematics lessons that are valued by primary pupils and teachers. The study involved six "Excellent Teachers" and thirty six pupils. Three lessons of each teacher were observed. During the observation, selected pupils took photographs of the moments they perceived the lesson as effective. Then, a focus group photo-eliciting interview was conducted with pupils followed by in-depth interview with the teacher. Preliminary analysis of the data showed that the primary pupils valued "concrete examples", "learning through mistake", "board work" and "shortcut and tips".

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***Keywords*:** Effective mathematics lesson; Primary pupils; Excellent teacher; Photovoice; Sociocultural

1. Introduction

Mathematics is an important subject in school. It is also the hope of every mathematics teachers that their pupils score well in mathematics. However, some pupils do not score well while others are not interested in learning mathematics. Many research studies (e.g. Seah, 2007; Cai, Perry, Wong, & Wang, 2009; Shimizu, 2009) have been carried out to search for effective mathematics teaching strategies or mathematics lessons. Most of these studies have been targeting on teachers, for example, mathematics teachers' classroom instruction (Li, 2007; Stigler & Hiebert, 1999); teachers' mathematics content knowledge for teaching (An, Kulm, & Wu, 2004; Ma, 1999); and teachers' beliefs on effective mathematics teaching (Cai et al., 2009).

There are some studies (Shimizu, 2009; Mok, 2009) that focused on both the teachers' and pupils' perspectives on mathematics classroom instruction. Shimizu (2009) carried out a study to examine the key characteristics of exemplary lessons which involved three teachers and 60 eight-grade students. His finding indicates that Japanese teacher valued "structured problem solving" approach of teaching in the mathematics lesson. In this approach of teaching, the lesson was made up of several segments: such as posing a problem; students solving problems by their own; whole class discussion; summing up the lesson; and exercise or extension. Shimizu used a story or a drama as a metaphor of a good mathematics lesson where there were a starting point, climax and summary of the whole story. The findings from students' interviews showed that they valued understanding/ thinking, presentation, classmates, whole class discussion and teacher in the lesson. The characteristics valued by the students are correlated with the intention of the teacher. Both teacher and students valued the co-constructed classroom practices by teacher and students as a "good" lesson, such as the teacher and the students have the same goal, the students understand the content well by discussing with the teacher or classmates, and the students listen carefully and make a good note when the teacher summarizing and highlighting the main point of the lesson.

Likewise, the study carried out by Mok (2006) shows a match between the teacher's and students' perception on element of important in the lesson. Both parties emphasized on the content of the lesson and the directive nature of the teaching. These two studies (Shimizu, 2009; Mok, 2009) focus on Grade-8 students and their teacher. However, there is yet similar study carried out

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in Malaysia. Since primary mathematics provides crucial foundation for pupils, the focus of this study will be on primary school teachers' and pupils' perspective on effective mathematics lessons.

The theory that underpins this study is the sociocultural theory proposed by Vygotsky. Mathematics classroom is a micro sociocultural context (Abreu, 2000). The process of teaching and learning of mathematics is sociocultural practice that occurs in the mathematics classroom. Pupils participate in the mathematics lessons to learn mathematics concepts and knowledge (Vygotsky, 1978). This theory put priority to social dimension of learning. As described by Vygotsky (1978, p. 57), "The interpersonal process is transformed into an intrapersonal one. Every function in the child's cultural development appear twice: first on the social level, and later, on the individual level; first, between people (interpsychology), and then inside the child (intrapsychology)". As pupils participate in the mathematics lessons, they interact with others who are more competent, teacher or peers, to learn mathematics concepts. Besides verbal interactions, pupils also learn through observation of the mathematics activity in the mathematics classroom. For example, after observing the procedures used by the teacher to solve the mathematics problems, pupils imitate the steps used by the teacher.

All the social interaction in the mathematics classroom (interpersonal process) and mental thinking (intrapersonal process) are mediated by signs or tools. Tools used in the mathematics classroom include rulers, calculators, calendar and so forth. Symbolic signs that were used in the mathematics lessons by teacher and pupils include mathematical idea, such as counting, mnemonic techniques and algebraic symbol system; and non mathematics ideas, like language, works of art, writing, schemes, diagrams, maps. These symbolic signs and tools are created by human culture overtime and made available to succeeding generations, which modify these artifacts before passing them on to future generations.

The main objective of this study is to explore the characteristics of primary mathematics lessons that are valued by teachers and their pupils as effective. This paper only focuses on the data collected from one Chinese school. During the writing of this paper only two cycles of data collection (please refer to procedure of data collection for more information) were conducted. Therefore, this paper focuses on preliminary analysis of data collected from two cycles of data collection in one Chinese school.

We acknowledged that based on one case study that involved only one teacher; the findings might not be able to be generalized. Nevertheless, the data did provide a glimpse of a real classroom practice of an excellent teacher and what her pupils valued about. Hence, the characteristics identified as discussed above might be useful as a guideline for pre-service as well as in-service teachers when they are preparing lessons for primary pupils.

2. Methodology

2.1. Participants

This study involved six "Excellent Teachers" ("Guru Cemerlang", in Malay) and 36 primary pupils. The six "Excellent Teachers" are selected from three different kinds of schools in Malaysia, two each from the National school (SK), the National Type Chinese school (SJKC) and the National Type Tamil school (SJKT). Each of the six teachers then selected six Standard 4 or 5 pupils from their class to participate in the study. Standard 4 or 5 pupils were chosen to take part in the study because they were considered mature enough to response in the study. The selected pupils consisted of two high, two moderate and two low academic performance pupils. They were named as A1 and A2 for high academic achievement pupils; B1 and B2 for moderate academic achievement pupils; and C1 and C2 for low academic achievement pupils.

This paper only discusses on the lessons of one Chinese Teacher, Mrs. C. She has more than twenty years of mathematics teaching experiences. She was awarded as "Excellent Teacher" since 2001. The six pupils selected by the teacher consisted of three boys and three girls.

2.2. Methods of data collection

The methods used to collect data in this study included photovoice, lesson observation, focus group interview with pupils and in-depth interview with teachers. During the lesson observation, researchers were sitting at the end of the classroom to observe the practice of teacher, the interaction between pupils with teacher and other pupils, and the materials used in the lessons.

Interviews were conducted with the teacher and pupils after the lesson observations to obtain the pupils' and teachers' perspective on the characteristics of effective mathematics lessons. According to Gay and Airasian (2003), through interview, the researchers able to gain the information that are hardly obtain from observation, such as experiences, feelings, concerns and values. Ritche and Lewis (2003) mentioned that "the aim of in depth interview is to achieve both breadth of coverage across key issues and depth of coverage within each" (p.148). Therefore, in-depth interview was carried out with teachers in order to get both breadth and depth coverage of the characteristics of effective mathematics lessons that are valued by them.

Photovoice is a method of data collection that utilized photographic technique which was originated from Wang and Burris (1997). This method was increasingly popular in the research with children (e.g. Fitzgerald, Bunde-Birouste, & Webster, 2009; Shankar-Brown, 2008; Epstein, Stevens, McKeever, & Baruchel, 2006; Darbyshire, MacDougall, & Schiller, 2005). However, these studies usually modified and adapted the process of photovoice to their research questions and research objectives. The process of photovoice was modified in this study also. We required the participating pupils to take photographs of moments in the lessons they perceived as effective. Focus group interview with the pupils was conducted after the observed lesson based on the photographs taken by them; therefore, we called this interview as focus group photo-eliciting interview. Photovoice was adapted in this study because this method able to eliminate the language barrier of pupils and invite the pupils to talk during interview. Interview with pupils was conducted in group so that they can discuss and articulate their perception on the characteristics of effective mathematics lesson (Darbyshire et al., 2005).

For each of the "Excellent Teacher", at least three lessons were observed. The lessons were chosen by the teacher that they confident they able to teach effectively. At the first cycle, six pupils were gathered in a room for a briefing before the observed lesson started. Six of them were briefed on the objectives of the study, their responsibility of taking photographs during the lesson and the ways of using cameras. Besides, they were interviewed regarding the characteristics of mathematics lessons they valued as effective.

During the observed lesson, the six pupils sat on their seat and followed the lesson as usual. They took photographs on moments or episodes that they perceived as effective. Two video cameras were used to record the lesson, one focus on the teacher and another one focus on the pupils.

After the lesson, the six selected pupils were gathered in the room again for focus group interview based on the photographs taken by them during the lesson. The interview was followed with an in-depth interview with the teacher referring to the photographs taken by the pupils. All observed lesson, focus group interview with pupils and in-depth interview with teacher were video-recorded for data analysis. In the second and third cycle, the focus group interview with pupils before the lesson was not carried out. The process started with lesson observation, followed by focus group interview with six pupils and in-depth interview with teacher.

3. Findings and discussion

3.1. The Observed Lesson

3.1.1. The first lesson

The first lesson observed was about the "Multiplication of a 5-digits number with a 1-digit number". The teacher started the lesson by testing the pupils' memorization of multiplication table. Then, she used the boxes of chalk to tell a story in order to revise the pupils' concept of multiplication. Before starting the topic, the teacher gave some pupils some small piece of papers with questions (multiplication of 4-digit number with 1-digit number) and asked them to solve the problems on the blackboard. Next, the teacher started the first activity by asking the four pupils to role play as wholesalers to buy newspapers. The amounts of newspapers they bought were the same. Pupils were asked to calculate the total number of newspapers that these four wholesalers have bought. In the second activity, seven pupils role play as managers of a supermarket. They were ordered by the boss to buy different kind but same amount of stock for Chinese New Year. Pupils were asked to calculate the total amount of stock that these seven managers bought. The last activity was the teacher gave pieces of papers with different questions (multiplication of 5-digits number with 1-digit number) to some pupils and asked them to solve the questions on the blackboard. The lesson ended up with the summary made by the teacher and the teacher gave the pupils homework.

3.1.2. The second lesson

In the second lesson, the teacher taught "Conversion of fraction into percentage". The teacher started the lesson by recalling the pupils' prior knowledge on percentage. Then, she pasted a blank manila card on the blackboard. She pasted a transparent plastic with one line at the centre on the blank manila card to show half of the manila card. The pupils able gave the answer ½. But only some of them know the way of converting ½ to 50%. The teacher then pasted the transparent plastic on another manila card with one hundred squares and explained the conversion of ½ to 50%. Next, every pupil was given one cards with one hundred squares. Each group of pupils were given a fraction. Pupils are required to colour the cards according to the fraction given and convert the fractions into percentage. After the pupils finish, some pupils were called out to show their solution. Their solutions were discussed and corrected if they answered wrongly. At the end of the lesson, homework was given by the teacher. Teacher walked around the classroom to help the pupils when the pupils were doing their homework.

3.2. Results and Discussion

Preliminary analysis of the pupils interview data showed that the pupils valued "concrete example", "learning through mistakes", "boardwork" and "shortcut and tips" as the characteristics of effective mathematics lesson.

3.2.1. Concrete example

Pupils from all the three groups valued their teacher to use concrete example to teach them. During the first lesson, the teacher told the pupils a story. In the story, when the school opened, headmaster gave every class two boxes of chalks. There were two hundred chalks in each box. When asking the pupils to calculate the total number of chalks every class got, most of the pupils used multiplication while some of the pupils used addition to calculate the total number of chalks. Based on the response of pupils, the teacher concluded that multiplication was also addition. But, multiplication was a faster way when calculating the repetition of same numbers if compared to addition. As shown in the utterances of pupils below, the pupils valued the teacher to use to boxes of chalk to explain the concept of multiplication.

A1: Teacher was teaching us multiplication… teacher was teaching us multiply, that what multiply with what, she used the boxes of chalk to demonstrate.

B2: She used some boxes of chalk to demonstrate, there were two hundreds chalks in the box.

C2: Use real object to demonstrate.

3.2.2. Learning through mistakes

Pupils from all the three groups valued the teacher corrected their mistakes as effective. In the first lesson, pupils were called out to solve multiplication questions on the blackboard. One of the pupils answered the example wrongly. So, the teacher corrected and explained the solution step by step. As shown in the A1's utterance below, pupils valued the teacher highlighting their mistakes.

A1: Er… Teacher also was telling pupils where the mistake was.

While B1 stated that when the teacher correcting their mistakes, they will be able to realise their mistakes.

B1: Correcting the mistake.
Interviewer: So you think teacher helps pupils to correct their mistake is very important?
B1: Yes.
Interviewer: Oh, why?
B1: Because [she] wants to let us know where is our mistake.

In the second lesson, teacher gave a card with one hundred boxes to each pupil. Then, she asked them to divide the card into equal proportions, color the proportions according to the fraction given and calculate the percentage. One of the questions given was 7/25. After the class finished the question, teacher selected two pupils' solutions and presented on the blackboard. The first card was divided into twenty five partitions (because the denominator is twenty five) and seven partitions were colored. Twenty eight boxes were colored, so the answer was 28%. The answer was correct. The second card, colored in orange, was divided into one hundred partitions. Therefore, the solution was wrong. Teacher pasted these two cards on the blackboard and compared the correct and wrong answers.

The teacher corrected their answer by comparing the correct and wrong answers. According to them, when the teacher compared the correct and wrong answers, they would know which one was correct solution and which one was wrong solution.

C2: Because can let us know……
A1: What was wrong and what was correct.
A2: Ya, right.
Interviewer: Oh, so you can learn from that, is it?
A1, B1, B2 & C2: Ah, right.

Different ways were used by teacher to correct the pupils' mistake in the classroom, which included step-by-step explanation and comparison of correct and wrong. Both methods were valued by pupils as effective. This aspect was also valued by students in the study carried out by Kaur (2008) and Mok (2006). The students valued the teacher giving them feedback and correcting their mistakes because these steps help them to learn. Similar findings were also evidenced in Lim (1996) that aimed to explore the pupils' perception on learning through mistakes by using questionnaire. In her study which involved 149 Secondary Four students, she found that more than 70% of pupils agreed that learning through mistakes help them in understanding mathematical concept better and alert them to be more careful when doing mathematics.

3.2.3. Board work

Board work referred to pupils presenting their solutions or work in front of the classroom or on the blackboard. In this study, board work was valued by pupils from high, moderate and low academic performing group. According to A1, their teacher called pupils to come out and present their solution on the blackboard so that the pupils will try to answer the question.

A1: Because she wants the pupils to try doing the exercise.

In addition, B1 perceived that they can check for their understanding of the concept learnt when they presented their solution on the blackboard.

B1: No, teacher, he also can come out and try to solve the problem, and check if you know to do or not.

While A1 valued board work as effective because teacher would correct their mistakes whenever they answered wrongly.

A1: She asks pupils to come out and solve the problem, if the pupil answers wrongly, she will correct.

Hence, the pupils perceived "board work" as a characteristic of effectiveness because they can check their own understanding when answering the questions in front of the classroom. Besides, they can receive immediate response and correction from the teacher when they made mistakes during presentation on blackboard. Likewise, pupils come out and present their ideas or solution in front of the classrooms to others was one of the major elements valued by pupils from Australia (Seah, 2007) and Japan (Shimizu, 2009).

3.2.4. Shortcut and tips

During the second lesson, the teacher taught "conversion of fraction into percentage". The pupils were taught to convert the denominators to one hundred in order to get the percentage. For example,

$$\frac{7}{25} = \frac{7 \times 4}{25 \times 4} = \frac{28}{100} = 28\ \%$$

Equation 1

After giving a series of examples for the pupils to solve, teacher wrote a series of formula on the blackboard, as shown below:

$$2 \times 50 = 100$$
$$4 \times 25 = 100$$
$$5 \times 20 = 100$$
$$10 \times 10 = 100$$

Equation 2

The teacher requested the pupils to copy these formulas in the exercise book. Pupils from good and moderate academic performance group took photographs of these formulas written on the blackboard. According to them, they valued these formulas because they would be able to answer the problems of conversion of fraction into percentage if they memorize these formulas.

4. Conclusion

In this study, we sought to identify the characteristics of mathematics lesson valued by pupils as effective and our data showed that characteristics such as "concrete examples", "learning through mistakes", "board work" and "shortcut and tips" were the most significant things valued by pupils. It was interesting to observe that while pupils from all the three academic performance groups valued "concrete examples", "learning through mistakes", "board work", only pupils of moderate and high academic performance valued "shortcut and tips". Perhaps, this might be due to pupils who have good and moderate academic achievement prefer "shortcut and tips" that offer them simpler, faster and more accurate ways when solving mathematics problems, which ultimately allow them to score better in the examinations.

Using concrete examples as one of the characteristics for effective mathematics lessons is plausible since pupils at the primary level are still at the stage of concrete operational (according to Piaget, 1954). Pupils will find it easier to understand and to grip the concepts if teachers provide them with concrete examples and real experiences. This is also in line with what have been advocated by Bruner (1966) about using the three modes of representation: enactive, iconic and symbolic for effective instruction.

The finding of this study shows that learning through mistakes is also another significant characteristic of effective lesson. This finding was coherent with what have been found in some studies (such as Kaur, 2008; Mok, 2006 and Lim, 1996) as discussed earlier. In fact, Lim (1996) explained that learning through mistakes provides several advantages in pupils' learning of mathematics. This step motivates the low esteem pupils when they realized they were not the only one doing the ridiculous mistakes. Besides, pupils realized their misconception or mistakes they have done and improved their understanding of abstract mathematical concepts when mistakes were highlighted and corrected.

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